Renewable and Sustainable Energy Reviews 13 (2009) 2192–2196

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Power sector of Oman—Today and tomorrow

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ARTICLE INFO

Article history:
Received 17 November 2008
Received in revised form 11 March 2009
Accepted 25 March 2009

Keywords:
Oman
Electricity companies
Renewable energy
Demand-side management

ABSTRACT

In December 1999 the council of Ministers of Sultanate of Oman approved policies for the wholesale restructuring and privatization of the sultanate's electricity and related water sectors. The government started carrying out unbundling of the sector and setting up independent companies on a commercial basis. The companies are now shaping up for future electricity market. Beside these evolving structural changes, there would be a need to change their generation mix. Oman relies 100% on fossil fuel resources (mainly gas) for its power generation. However, Oman's natural gas supplies are largely committed and the country may become a net natural gas importer in the near future. Today, there is a great incentive for Oman to exploit renewable energy in order to face the changing environment and to guard against future trends. The electricity companies should investigate the renewable potential and work with Omani government and Authority for Electricity Regulation (AER) to establish policy support for large-scale renewable energy plants. Beside there is a huge potential for demand-side management and energy conservation which should be exploited for the benefit of the country and of the environment.

Contents

1. Introduction

Oman excellent geographic location accessible by air, land and sea makes it attractive to global investors in energy sector as well as in other sectors. Oman's economy is heavily dependent on oil and gas revenues, which account for about 81% in 2006 of the country's export earnings and 48.6% of its gross domestic product (GPD) [1]. The residential sector is the largest consumer category with its consumption taking more than half of the total system energy. However, the industrial sector is the fastest growing part with an annual growth rate of 14.4% in comparison to non-industrial sectors which has growth rate of 6.3% [2].

The electric power sector of Oman has undergone significant structural changes to promote and infuse private capital into power sector. For that purpose, AER Oman was established subject to Audit Law by the Article (19) of the sector law. A sector law was announced by the Royal Decree 78/2004 on the first of August 2004 to oversee the development of law for regulation and privatization of the sultanate's electricity and related water sector. The Authority is responsible for regulating the electricity and related water sector in Oman. The Authority has a range of legal duties including:

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doi:10.1016/j.rser.2009.03.010

- Securing the provision of electricity in all parts of Oman;
- securing and developing safe, effective and economic operation of electricity sector as well as a duty to afford due consideration to the protection of environment.

The sector law implements a new market structure, paves the way for further electricity privatization, and establishes an independent regulator to oversee the public interest regulation of the sector. The government started carrying out unbundling of the power sector and setting up of independent companies on a commercial basis. On May 1st, 2005, the Ministry of National Economy implemented a transfer scheme whereby the electricity and related water assets, liabilities and staff of Ministry of Housing Electricity and Water (MHEW) are transferred to the successor companies. The successor companies are a holding company, four generation companies, three generation and desalination companies, one transmission company, three distribution and supply companies, a company servicing the rural areas and a single power and water procurement company. With the exception of the electricity holding company, the successor companies are now responsible for the electricity function previously undertaken by MHEW [3].

The three main segments of the new market structure, and the companies that operate in them, are shown in Table 1. The electricity and related water sector comprises both government owned and private sector companies.

Oman is planning to build several power stations to meet the demand requirements, Oman Power and Water Procurement (OPWP) Company has announced the building of five new power and water desalination plants in different areas. Two of these projects will be located in the Northern part of Oman, one in the Southern part, one in the capital and the fifth one in Al-Duqm region.

2. Oman power system

The energy demand in the Sultanate is supplied by the following main systems:

Table 1
Electricity and related water sector market structure.

Main interconnected system			
Generation and Generation/desalination	Power and water procurement	Transmission and dispatch	Distribution and supply
AL Rusail power company (G)	Oman power and water procurement company	Oman electricity transmission company	Muscat electricity distribution company
Wadi Al Jizzi power company (G)			Majan electricity company
United power company (G)			
Al Kamil power company (G)			
AL Ghubrah power company (G/D)			Mazoon electricity company
AES Barka (G/D)			
Sohar power company (G/D)			
Rural systems			
Generation/desalination	Transmission		Distribution and supply
Rural areas electricity company			
Salalah power system			
Generation	Transmission		Distribution and supply
Dhofar power company			

1. The main interconnected system (MIS) serves the majority of people in Oman (almost 500,000 accounts). The system interconnects seven main power plants with around 3000 MW of net generation capacity and transmits power over 220 and 132 kV lines. The fuel used to run these power plants is natural gas.
2. The Salalah system covers Salalah and surrounding areas in the Dhofar region, south of Oman, serving around 50,000 accounts. The generation capacity is around 312 MW. The electrical power is generated in Salalah mainly by natural gas.
3. The remaining of scattered rural areas of Oman is provided with the electrical power by mainly diesel generators, with total installed capacity of 1000 MW.
4. Petroleum Development Oman (PDO), the main oil company in Oman has its own dedicated system of 618 MW.
5. There are also other companies that produce power for their own needs; such as Oman Mining Company, Oman Cement Company, Sohar Refinery, Sohar Aluminum Company, Ministry of Defense, Occidental of Oman, etc.

The annual demand curve reflects the climate in Oman and is highly seasonal. The average summer demand is more than double of the average winter demand, owing to the increase in residential demand during the hot weather in summer. The demand peaks typically in July reflecting the highest temperatures and intensive use of air-conditioning. The peak demand reached 2773 and 2614 MW in July 2007 and 2006, respectively, as depicted in Fig. 1. In the future, a reduction in the demand seasonality is expected to reduce due to new large industrial loads coming on line. Daily load profile has a distinct shape. Peak hours are between 3 and 5 pm, and again between 11 pm and 4 am in the summer. In the winter there is a lower peak at 8 pm.

The demand projections in the future are expected to increase due to the following two main factors:

1. The increase in population, rising personal incomes, and general economic development.
2. The government policy for diversification of the country economy has resulted in new large industrial and tourism projects. New industries and tourism projects are expected to be built in different places which will require substantial power demand.

The peak demand is expected to reach 5288 MW in 2013 with an average annual growth rate of 11%, as shown in Fig. 2 [2].

3. Electricity consumption and supply by different companies

For 2007, the total energy supplied by Muscat electricity company was 4,819,763, 2,160,097 MWh by Majan company and 2,774,889 MWh by Mazoon company. Therefore, the demand by

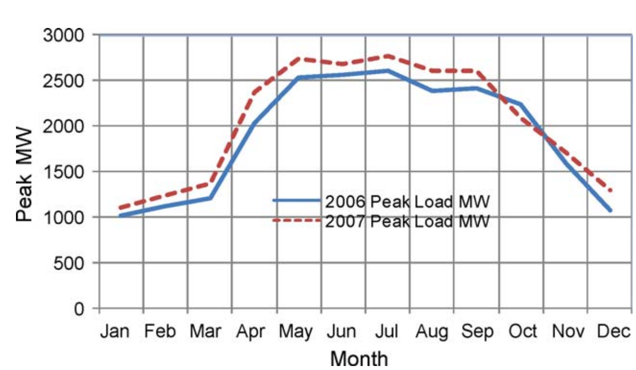


Fig. 1. Main interconnected system peak demand for 2006 and 2007.

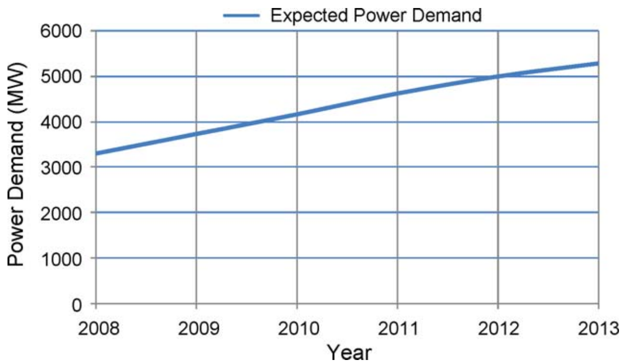


Fig. 2. Expected peak power demand in the main interconnected system.

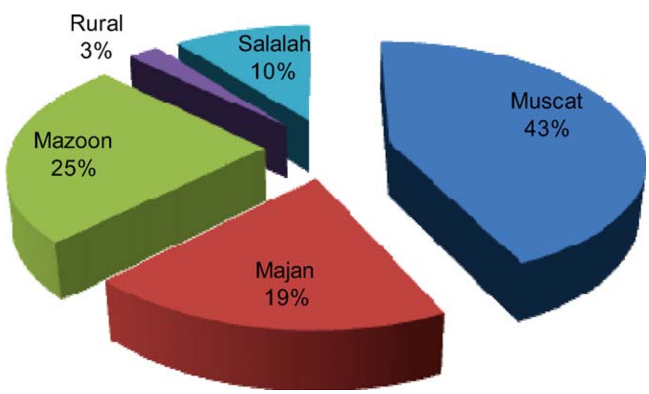


Fig. 3. Total energy supplied in Oman by different electricity companies.

the Main Interconnected System was 9,754,749 MWh. For rural areas electricity company (RAEC), the supply was 272,089 MWh and for Salalah system was 1,162,447 MWh. The total energy supplied in Oman was 11,189,286 MWh in 2007, as presented in Fig. 3 [4].

3.1. Oman transmission system

The transmission system of Oman electricity transmission company has two voltage levels 132 and 220 kV, covering 2719.3 and 596 km, respectively [5]. The peak load of the grid reached 2773 MW as of July 2007, the total area covered by the system was 129,344 km^2, with 38 stations.

3.2. MIS distribution system

There are three bulk electricity supply customers. A brief detail of each of these distribution companies is provided below:

Distribution system for Muscat electricity company (*MEDC*): MEDC owns and operates the electricity distribution network from the 33 kV circuit breakers on the outgoing feeders at the grid stations down to the customers point of supply which include 33, 11 kV and low voltage distribution networks [6].

Distribution system for Mazoon electricity company: The distribution system of Mazoon electricity company consists of the following voltage levels 33, 11 and 0.433 kV. These voltage categories are working on various 33/11 kV primary substations, 11/0.433 kV distribution substation and 33/0.433 kV substations [7].

Distribution system for Majan electricity company: The distribution system of Majan electricity company consists of the following voltage levels 33 kV covering (1502 kM), 11 kV covering 5229 km and 0.433 kV covering 5449 km. These voltage categories are working on various 33/11 kV primary substations, 11/0.433 kV distribution substation and 33/0.433 kV substations [8].

4. Load shedding and system losses

The load shedding takes place during summer time in Oman where the air conditioners' load is very high and the temperature is also high, but it does not happen all the time since it is controlled and regulated. The technical and non-technical system losses were reduced from 21.4% in 2006 to 20.9% in 2007. This decrease resulted in a costs savings of more than 1 million Omani rail. For 2007 the losses distribution in the different systems were as follow: in Muscat distribution system the total losses were 21.8%, Majan system were 19.2%, Mazoon system were 23.2%, so the total losses in main interconnected system were 21.6%. Losses in rural area electricity company system were 16.9%, whereas the losses for Salalah system were 16.2%. The total power system losses in Oman for 2007 therefore were 20.9% [4]. While some degree of technical losses is unavoidable, non-technical losses should be investigated and means should be devised to reduce it to an acceptable level.

5. Future and existing resources for power generation and energy requirements

In addition to the existing firm capacity of 2773 MW in 2007 provided by the different generating companies and ensured by the power purchase agreements with the current production plants, another 1262 MW of new contracted capacity will be added to the main interconnected system by 2010 from Sohar and Barka II plants. The Sohar plant has been commissioned and has added 585 MW in April 2007. Also, OPWP recently entered into an agreement for the development of the Barka II power and desalination plant. The new capacity from Barka II is to be commissioned in two phases reaching 677 MW by 2009. There are other sources of capacity. These include the Abu Dhabi interconnection, Sohar Aluminium generation facility, and capacity from non-contracted units in Al Ghubrah and Wadi Al Jizzi. The required additional capacity needed to satisfy the demand is 425 MW in 2010, increasing to 1845 MW in 2013 under the "high" case according to the OPWP forecast. These needs for additional contracted capacity could be met by contracting for some of the non-contracted capacity and/or by the construction of new capacity. OPWP expects most of the additional contracted capacity to be new-build capacity [2].

For the Salalah power system, in addition to the existing capacity of Dhofar power company (DPC) and the addition of the two gas turbines with a capacity of 49 MW, OPWP has estimated a need for a minimum of about 370 MW of additional capacity by 2013.

The government of Oman is currently evaluating other possible future sources for electricity production. This includes nuclear power, coal generation and renewable energy sources such as wind energy, solar energy, bio-mass, and others. Oman is planning to build the following power stations:

1. Al-Duqm power and water desalination plant with capacity of 1000 MW, it is expected to be operated by 2015. It may be based on coal due to rising price of natural gas.
2. Taqah (in the South of Oman near Salalah) power and water desalination plant with a capacity of 400–430 MW. This plant is expected to start commercial production in 2011.
3. A new power and water desalination plant in the north of Oman with a capacity of 1300 MW and water desalination with a capacity of 55,000 m^3/day. It is expected to start commercial production in 2012.
4. The Barka II Independent Water & Power Plant (IWPP) will be implanted in two phases:
   i. Phase 1 with net power generating capacity of 363 MW.

ii. Phase 2 with net power generating capacity of 678 MW with a simultaneous desalination capacity of 120,000 m^3/day. It is expected to start commercial production by April 2009.

5. The existing Al-Gubrah power and water desalination plant is based on open cycle gas turbine. To improve the overall fuel efficiency and to increase the potable water and power capacity, the open cycle will be converted into combined cycle gas turbine. Additional power and water desalination plant will be added to meet the future demands. The proposed new capacity will be located to the west of the existing station and will have a capacity of 500 MW by utilizing the same gas consumption rate of the existing plant, with minor increase. The new plant is expected to start commercial production in 2013.

6. Tariff structure

The electricity tariffs in Oman are subsidized and do not reflect the true cost incurred in generating, transmitting and distributing a kilowatt-hour of electricity at the consumer end [9]. For commercial customers and for the Ministry of Defense a flat rate of 20 Baiza per kW h is charged. For agriculture and fisheries, for energy consumption range from 0 to 7000 kW h the charge is 10 Baiza/kW h and for 7000 kW h and above the charge is 20 Baiza/kW h. Residential, government and tourism are charged based on the usage rate as follows: 0–3000 kW h at 10 Baiza/kW h, 3001–5000 kW h at 15 Baiza/kW h, 5001–7000 kW h at 20 Baiza/kW h, 7001–10000 at 25 Baiza/kW h, and above 10,000 kW h is 30 Baiza/kW h. Industrial customers are charged based on a summer rate of 24 Baiza/kW h and winter rate of 12 Baiza/kW h.

7. Power exchange with neighboring countries

There is a plan to interconnect Gulf Cooperation Council (GCC) countries. The GCC Interconnection Grid shall be developed in three (3) phases, namely:

Phase I: Interconnection of Kuwait, Saudi Arabia, Bahrain and Qatar. This system is the GCC North Grid.
Phase II: Interconnection of the Independent systems in the UAE as well as Oman. This is the GCC South Grid. In 2006, the international interconnection between the two countries was completed and awaiting for commissioning [5].
Phase III: Interconnection of the GCC South Grid with the GCC North Grid. This phase completes the interconnection of the six (6) Gulf States.

As per 2003 record, the GCC load level was 32 GW. It is expected that by 2010, the load level will rise to 49 GW. The estimated increase in the load demand in the 7-year period is 53%.

8. Demand-side management and energy conservation

Demand-side management (DSM) and energy conservation programs consist of the planning, implementing, and monitoring activities of electric utilities that are designed to encourage consumers to modify their level and pattern of electricity usage. In the past, the primary objective of most DSM programs was to provide cost-effective energy and capacity resources to help defer the need for new sources of power, including generating facilities, power purchases, and transmission and distribution capacity additions. However, due to changes occurring within the industry, electric utilities are also using DSM to enhance customer service [10].

The first DSM study in Oman (1998), "The Study on Demand Supply Management for Power Sector in Sultanate of Oman", was conducted by Japan International Cooperation Agency (JICA). The study identified several strategies for potential load management including (i) gas cooling systems for Government buildings, hospital, hotels commercial complexes and large houses; and (ii) shifting load from peak time to off-peak time in the industrial and commercial sectors by application of ice thermal storage system and introducing time-of-use tariffs [11]. The utility benefit was estimated using avoided marginal generation capacity and energy cost concept. The study recommendations were never implemented, however. There has been another theoretical study that estimated the DSM energy saving and load management potential in commercial and government/institutional sectors in Oman (MIS area) and evaluated its impact on generation capacity and energy savings [12]. The study found that DSM is financially beneficial from customers' point of view as the discounted payback period of investment in efficient lighting and air-conditioning is between 4 and 12 years of the surveyed sample (even with the subsidized tariff). From the utility point of view the capacity saving at the horizon year (2024) is between 372 and 596 MW and the overall energy saving for the whole planning horizon is about 29–44 TW h. The total avoided cost in generation and capacity saving is somewhere between 416 and 597 million dollars.

Although electricity companies in Oman are working on implementing some energy loss reduction programs to improve their operation and become more competitive. There has been no serious effort from the Government side to implement time-of-use tariffs or offer rebates to encourage customers to buy efficient end-use appliances. On the contrary there are large subsidies in tariffs especially in the residential and commercial sectors which are the main hurdle in the implementation of DSM. In authors' view there is a huge potential for DSM and energy conservation in all the energy sectors of Oman and the Government should take steps to implement measures and standards to promote DSM and energy conserving culture.

9. Conclusions

Based on OPWP's statement, the 2007 firm capacity was 2773 MW but the power demand is expected to grow from the existing capacity by 9% a year in the MIS, while the Salalah system increased by 14%. The total gross electricity production for the Main Interconnected System was 12,882.5 GW h, in the rural area system 309.4 GW h, and in the Salalah System was 1,406.5 GW h. Oman's investment climate is strong, political risk and corporate tax are low, and the private sector has been involved in electricity generation since 1996. More government involvement would be needed to promote other alternative energy services sector by establishing energy sector policies that support renewable energy. Specifically, government financial support for feasibility studies, increased research, deployment through international partnerships and further economic analysis would be essential for shaping the future of alternative energy sector. Furthermore, the government should participate in carbon markets as these markets are expanding and are a source of finance for energy sector projects.

Oman's solar potential is excellent, although it is highest in remote area away from major population centers, whereas its wind resources are mainly in the southern part. The burning of municipal and industrial waste as well as the capturing of methane gas produced during the decomposition of waste in landfills could be also an option for electrical energy production.

Small projects should be initiated to power rural areas by using wind energy, solar energy or both systems (hybrid system). There should be some incentive to encourage people to generate energy in their houses using solar or wind energy. The AER should also discourage the usage of electrical water heater and issue regulation on using of the solar water heater. Large-scale solar thermal power plants should be developed by government and/or private sector.

There is a huge potential for demand-side management and energy conservation and the Government should take steps to implement measures and standards to promote DSM and energy conserving culture.

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